# Spectral line scaling

Problem 1: Using a simple spectrograph attached to a telescope, an astronomer recognizes the lines in a nebula from the element hydrogen as shown in the figure above. He knows that the bright 'Balmer-alpha' red line occurs at a wavelength of 656.3 nanometers (nm), and that the turquoise Balmer-beta line next to it on the left occurs at a wavelength of 486.1 nm. Using this information and a millimeter ruler, what is the horizontal wavelength scale of the spectrum in the figure in nm per millimeter (nm/mm)?

Problem 2: About what are the wavelengths, in nm, of the three other hydrogen lines, Balmer-gamma, delta and epsilon, in the blue part of the spectrum?
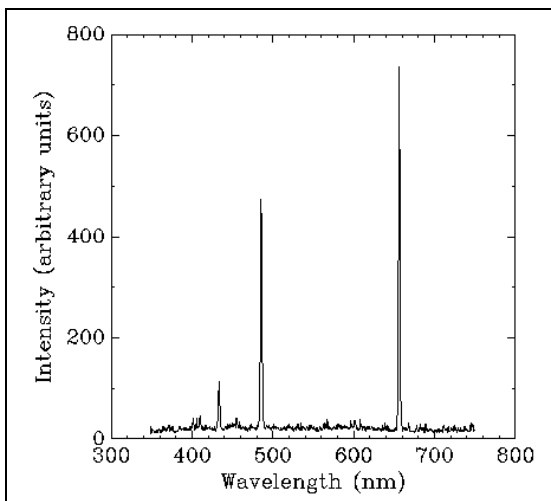
With modern day instruments, astronomers usually work with spectra in which the intensity of the line is indicated on the vertical axis, and the wavelength is along the horizontal axis like the one on the left. This spectral plot shows a portion of an atomic spectrum detected with an instrument called a spectrophotometer, that measures the intensity of the spectrum at each wavelength point from 300 to 600 nm.

Problem 3: From the spectrogram above, what is the wavelength scale in nm/mm?

Problem 4: What are the wavelengths of the three vertical 'lines' shown in the plot in nm?

Problem 5: Can you identify which element this spectrogram represents?

Problem 1 - Students should measure with a millimeter ruler, the distance in the picture between the first two lines. This is about 58 millimeters. The wavelength difference is 656.3 - 486.1 = 170.2 nm, so the wavelength scale is 170.2 nm /58 mm = 2.93 nm/millimeter.

Problem 2 - For example, measure with a ruler the distance, right to left, from the main line at 656.3 nm to the third line on the right (dark blue) to get 76 mm, then 76 x 2.93 = 222.68 nm. Because the wavelength decrease from right to left, subtract 222.68 nm from 656.3 nm to get 433.6 nm. Repeat this for the fourth line (purple) to get 84 mm, 246.1 nm and 410.2 nm; and for the fifth line (violet) to get 89 mm ,260.77 nm and 395.5 nm.

Problem 3 - The wavelength difference is 800 nm - 300 nm = 500 nm, and the distance between the marks is about 53 millimeters, so the scale is 9.43 nm/millimeters.

Problem 4 - 800 nm - 15mm x 9.43 nm/mm = 658.6 nm
              800 nm - 33mm x 9.43 nm/mm = 488.8 nm
              800 nm - 39 mm x 9.43 nm/mm = 432.2 nm

Problem 5 -   To within the measurement accuracy of the millimeter ruler, the wavelengths measured in Problem 4 are the same as the ones measured for hydrogen.

Balmer - Alpha	656.3 nm	vs	658.6 nm
Balmer - Beta	486.1 nm	vs	488.8 nm
Balmer - Gamma	433.6 nm	vs	432.2 nm